Review of NIOSH's Program Evaluation Report DCAS-PER-068, "Electro Metallurgical Company"

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DCAS-PER-068 purpose and review summary

- **Purpose:** Assess the impacts of rev. 01 of the Electro Metallurgical Company ("Electro Met") technical basis document (TBD) on previously completed dose reconstructions (DRs)
- **April 5, 2016:** NIOSH issued DCAS-PER-068
- **June 21, 2023:** Subcommittee for Procedure Reviews tasked SC&A to review the PER
- **January 30, 2024:** SC&A issued its report reviewing the PER

Electro Met background

- Electro Met, a Union Carbide (UC) ferro-alloy manufacturing plant in Niagara Falls, NY, was engaged by the Manhattan Engineer District to participate in the nuclear weapons program
- Operated March 1943–June 30, 1953, and was subsequently decontaminated and released
  - Estimated 50–70 workers
- Nuclear weapons portion occupied a single purpose-built, fenced-off, 50×219-foot single-story building (“The Area Plant”) on the much larger site
- Mission: convert uranium tetrafluoride (UF_4, “green salt”) into uranium metal
  - Received UF_4 from UC Linde Plant in Tonawanda, NY
  - Sent finished product and residues to several other nuclear weapons program sites

Electro Met process

- The conversion process from UF_4 to uranium metal:
  - Mixed the UF_4 with magnesium
  - Put the mixture into a metal “bomb” lined with dolomite (a refractory material)
  - Heated the bomb in a furnace to initiate a vigorous exothermic reduction reaction
- When finished, the bomb was opened, the uranium metal separated from the magnesium fluoride slag, and both components removed
- The uranium was then cast into 110–135 kg ingots
  - Later recast in a furnace into billets that were shipped off site for further processing
  - Also received uranium scraps from other facilities and remelted them into ingots

Operating history

Description	Start date	Stop date	Approx. uranium metal production rate, tons/month
Operations 1	8/13/1942	8/31/1946	44
Standby 1	9/1/1946	9/30/1947	N/A
Operations 2	10/1/1947	9/30/1949	26 (October 1947–June 1948) 35 (June 1948–June 1949)
Standby 2 – overall	101/1949	1/1/1951	N/A
Standby 2 – zirconium production	4/1950	9/1950	N/A
Operations 3	1/1/1951	6/30/1951	Not provided (research quantities)
Standby 3	6/30/1951	9/30/1953	N/A

Source: Adapted from Electro Met TBD, DCAS-TKBS-0007, rev. 01 (2015), table 2.
Note: SEC-00136 ER rev. 1 found that internal DR was not feasible 8/13/1942–12/31/1947.

Radiation source terms

- Uranium, uranium isotopes, and members of their decay chains (“progeny”)
- For example, U-238, with a 4.3-billion-year half-life, has a 13-radionuclide decay chain, with half-lives ranging from short to very long, ending in stable lead-208
- The radioactive material produced alpha, beta, and gamma radiation

SEC-00136 background

- NIOSH issued its petition evaluation report (ER) for SEC-00136 (rev. 0, 2009) for all workers in *any area* of Electro Met from 4/1/1943 through 6/30/1953, concluding that DR was feasible
- Following SC&A reviews and WG discussions, NIOSH revised its SEC-00136 ER (rev. 1, 2012) as follows:
  - Changed the SEC period evaluated to 8/13/1942–6/30/1953
  - Changed its determination of the feasibility of internal DR from 8/13/1942 through 12/31/1947 to not feasible; DR remained feasible after 12/31/1947
- More evaluations and discussions followed

SEC period

- Rev. 1 of the SEC-00136 ER defines a class of Electro Met employees to be included in the SEC class based on internal dose considerations:
  - "NIOSH finds it is not feasible to estimate internal exposures with sufficient accuracy for all workers at the site from August 13, 1942 through December 31, 1947. Internal monitoring data, work area radiological monitoring data, and source term data are not sufficient to provide a sufficiently accurate estimate of the bounding dose during this early period at Electro Metallurgical."
- The SEC period encompasses the entire first operations period, the entire first standby period, and part of the second operations period.

Internal monitoring

- After the SEC period, the AEC's New York Operations Office Health and Safety Laboratory conducted two large air sampling campaigns in November 1948 and August 1949
- In a claimant-favorable approach, NIOSH's TBD rev. 01 chose to use:
  - the higher 1948 sampling data, as the1949 sampling had open doors and windows as well as improved building ventilation systems
  - the highest air sampling data by job title (green salt room operator) as the assumed air concentration for all workers and operating periods
- Note: There was substantial floor contamination during operational periods and a lesser amount during standby periods

External monitoring

- Beta and gamma radiation from the decay of uranium isotopes and their progeny (alpha has too short a range to be considered)
- External exposures differed significantly for different job titles
- External dosimetry improved during the second operations period, and NIOSH collected data for 58 employees representing 21 job titles from June 1948 to September 1949
- Table 5 of Electro Met TBD rev. 01 (2015) shows all external dosimetry data by title for the 21 job titles

Subtask 1: Changes necessitating PER

- The following chronology summarizes the events leading to rev. 01 of the Electro Met TBD (2015), which prompted NIOSH to issue DCAS-PER-068 (2016) to assess DRs made prior to the TBD revision
- SC&A reviewed each of the documents leading to changes incorporated into rev. 01 of the TBD
- SC&A concurs that these changes and their impacts on worker doses support the need for PER-068

Events leading to PER-068 (1/2)

- **2006:** Battelle-TBD-6001, rev. F0, general guidance for uranium processing facilities
- **2007:** Battelle-TBD-6001, Appendix C, rev. 0, provides Electro Met-specific guidance
- **2009:** NIOSH SEC-00136 ER (rev. 0): DR is feasible
- **2010:** SC&A review of SEC-00136 ER issued
- **July 7 & Nov. 24, 2010:** TBD-6001 work group (WG) discussed SEC-00136 and SC&A's findings
- **2011:** Electro Met TBD rev. 00 issued as standalone document; no material change from TBD-6001, Appendix C
- **2011:** SC&A revised review (rev. 1) of SEC-00136 petition ER had 17 findings
- **May 16, 2011:** Uranium Refining AWEs WG discussed SC&A's review of the SEC-00136 ER
- **August 16, 2011:** NIOSH updated WG on its data gathering efforts and progress in responding to SC&A's 2011 SEC-00136 ER review

Events leading to PER-068 (2/2)

- **November 21, 2011:** At a WG meeting, NIOSH stated that it had reassessed its SEC-00136 petition ER and concluded it could not adequately reconstruct doses from 1942–1947 using back-extrapolation from the post-1947 period
- **2012:** NIOSH SEC-00136 petition ER rev. 1: Can't reconstruct internal dose
- **February 14, 2012:** WG discussed rev. 1 of SEC-00136 petition ER. SC&A preliminary analysis stated that DR might be possible for the SEC period. The WG decided to wait for resolution before making a recommendation to the Board.
- **2012:** SC&A issued an addendum to its 2011 review of the SEC-00136 petition ER in response to rev. 1 of the SEC ER (2012)
- **2015:** Electro Met TBD rev. 01, which was a major revision of rev. 00, incorporated greatly expanded DR guidance and SEC-00136 results
- **2016:** NIOSH issued DCAS-PER-068 because of rev. 01 of the TBD

Subtask 2: Assess corrective action methods

- SC&A has not formally reviewed rev. 00 or rev. 01 of the TBD but has tangentially reviewed them during its SEC-00136 ER evaluation
- Since the SPR had not tasked SC&A to perform a full TBD review, SC&A conducted a limited review focusing on PER-068, including examining and comparing the two revisions to see how the change from the earlier to the later revision might affect DRs
- The Records of Issue/Revisions section of TBD rev. 01 states: "Substantial update of the document with re-analysis of the external and internal dosimetry data. Constitutes a total rewrite of the document."

TBD issues review caveats

- SC&A's addendum (2012) to its previous report (2011) responded to the revised ER and contains an updated issues matrix of the 17 findings and SC&A's comments
- Although certain issues were discussed at WG meetings, there was no systematic review or disposition of the findings
- Findings are based on reviews and discussions of rev. 00, not rev. 01, and SC&A has not been tasked with reviewing rev. 01 to see if it resolves the findings made on rev. 00

SC&A overview comments on TBD rev. 01

- Rev. 01 (2015) substantially improves on rev. 00 (2011), which was a repackaging of Appendix C of Battelle-TBD-6001, rev. 0 (2007)
- Rev. 01 added material on the granted SEC-00136, incorporating many more monitoring and other data, and updating and expanding its methods and guidance, for example:
  - **Internal Dose:** Rev. 01 makes several very claimant-favorable assumptions in determining air concentrations and, therefore, resulting inhalation and ingestion doses; it adopts the 1948 air sampling dataset and choses air concentration data for a green salt room operator for all personnel in all operational periods
  - **External Dose:** A re-evaluation of data and information as a result of the SEC-00136 review process increased external photon dose rates for all years

External dose reconstruction guidance

- PER-068 states that changes in rev. 01 of the TBD “resulted in an increased external dose estimate for all claims completed using an earlier version. Because of this, it was not necessary [for the PER] to itemize any other increases in dose or further breakdown the time periods affected.”
- In light of that statement, SC&A examined NIOSH’s approach to assigning external doses. SC&A found that the revised external dose section contains much more information and guidance, expanding from about 1 page to about 13 pages.
- The revised section contains lengthy discussions of operations that affected external dose, available data, a table showing external dosimetry monitoring by job title, and a separate section providing detailed information on how to assign external dose.

Selected external dose guidance

TBD rev. 01 (p. 29):

- *Item 2*: “Photon and Beta dose during operations was determined using the 95th percentile of all badged worker data.”
- *Item 3*: “Photon dose during standby was determined using the geometric mean of all badged worker data.”
- *Item 4*: ““Non-penetrating dose to other skin is assigned based on the recommended 10 times the photon dose to account for incorrectly worn badges.”
- *Item 5*: “Beta doses to the hands and forearms during standby periods are determined using whole body skin doses (10 times the GM of photon dose).”
- *Item 6*: “The annual dose values shall be assigned as the geometric mean for the period with an uncertainty equal to a GSD of 3.”

Comparison of TBD rev. 01 and rev. 00 external dose assignments

TBD revision, period	Photon whole-body dose, mrem/yr	Nonpenetrating dose to other skin, mrad/yr	Nonpenetrating dose to hands and forearms, mrad/yr
Rev. 00, Operations	Operators: 3.934 Supervisors/Laborers: 1,003 Others: 256	Operators: 21,030 Supervisors/Laborers: 3,221 Others: 493	N/A
Rev. 01, Operations	All: 4,403	All: 44,030	All: 276,000
Rev. 00, Standby	All: 256	All: 493	N/A
Rev. 01, Standby	All: 1,356	All: 13,560	All: 13,560

Sources: TBD rev. 00, table 3. TBD rev. 01, table 7.

Subtask 3: PER selection criteria

- Since the number of previously completed DRs was small, NIOSH was able to examine all claims with a POC of <50%, which amounted to 63 cases
- NIOSH then deleted from consideration 25 of those cases that qualified for inclusion within the SEC
- After performing new DRs on the remaining 39 cases, NIOSH found that 19 of those still had POCs <45% and 20 had POCs >52%
- SC&A found this selection process valid and had no findings but notes that the PER arithmetic is slightly off as 25 + 39 = 64, not 63

Subtask 4: Audit of reevaluated DRs

SC&A recommends that the Board select two cases for production workers covering the operational periods with POCs still <45% after NIOSH reworked them.

Questions?